

by northeast gales. In the Twin Cities (St. Paul and Minneapolis) the storm was especially intense. On the southern side of the disturbance severe thunderstorms were a feature, accompanied by southwest to northwest gales. In portions of Kansas and Missouri some tornadoes occurred. An interesting feature of the storm was a deposit of "red mud" over a wide area, including at least eastern Iowa, southern Wisconsin, and northern Illinois.

Other special warnings issued during the month were those for stock interests in South Dakota, Nebraska, Kansas, and Wyoming on the 15th, and the western portions of Kansas and Nebraska on the 28th; also a heavy-snow warning for northern Missouri on the 16th.

Frost and cold-wave warnings for the benefit of the strawberry interests in southwestern Missouri were begun on the 15th, this being an annual feature of the work of this office. The season lasts until April 20.—*C. A. Donnel.*

NEW ORLEANS FORECAST DISTRICT

A cold wave of considerable severity overspread the greater portion of the district, extending to the coast, on the 9th and 10th, for which timely warnings were issued. Warnings which were verified were issued on the 13th for a cold wave on the Texas coast. Warnings were issued on the 16th, 17th, and 30th for cold waves which occurred over limited areas in the northwest portion of the district. Conditions were threatening on the 31st, and cold-wave warnings were ordered for the Texas coast; a decided fall in temperature occurred, but the lowest temperature was 42° to 46°. No cold waves occurred without warnings and no warnings were issued which were not justified.

Storm warnings were displayed on the Texas coast on the 9th, 13th, 17th, 22d and 28th, and on the Louisiana coast on the 13th and 19th. Storm winds occurred with each display on the Texas coast, but at New Orleans the velocities did not quite reach the requirement for verification. Small-craft warnings were issued for portions of the West Gulf coast on the 3d, 8th, 9th, 12th, 13th, 15th, 16th, 19th, 22d, 28th, and 31st, all of which were justified. No storms occurred without warnings and no warnings, except as needed, were issued.

Special wind warnings were issued on the morning of the 28th and distributed over the States in the district as follows: Louisiana, increasing southerly winds; Arkansas, thunderstorms, fresh to strong southerly winds, probably gales, this afternoon and tonight; Oklahoma, strong southerly winds this afternoon, shifting to northwest early Saturday; east Texas, fresh to strong southerly winds this afternoon and to-night, shifting to westerly Saturday. Damaging winds occurred in Arkansas, Oklahoma and northern Texas.—*I. M. Cline.*

DENVER FORECAST DISTRICT

The month was especially cold and stormy throughout, with a succession of lows advancing across the district from the Pacific coast or from the middle and southern portions of the Rocky Mountain Plateau.

On the morning of the 2d, when a disturbance of marked intensity was central over Nevada, livestock warnings were issued for western Colorado, northern New Mexico, northern Arizona, and Utah, snow and much colder weather, with strong shifting winds, having been forecast for that territory. Light snow, with considerably lower temperatures and fresh to strong shifting winds, attended or followed the passage of the storm eastward.

Livestock warnings were also issued on the morning of the 8th for southwestern Colorado and northern New Mexico, when another disturbance was central over that region. Light to moderately heavy snow, attended by strong shifting winds, occurred during the 8th in the territory designated, followed by a sharp fall in temperature that amounted to a cold wave at Santa Fe and Durango on the morning of the 9th.

On the morning of the 15th, when a disturbance of unusual intensity was central over western Colorado, with a pressure of 29.34 inches at Grand Junction and rapidly increasing pressures to the northward and northwestward, warnings of a moderate cold wave were issued for western Colorado, northeastern Arizona and southern Utah "to-night" and for northern New Mexico "to-night and Sunday." The warning was extended to southern New Mexico on the evening of the same date. The temperatures in northeastern Arizona and southwestern Utah were 20° lower on the evening of the 15th than at the same time on the 14th, with a minimum of 14° at Modena and of 18° at Flagstaff on the morning of the 16th. A sharp fall also occurred in the remainder of the territory for which the warnings were issued, but it was not sufficient to amount to a cold wave, another low that produced a modifying effect having begun to develop over Nevada during the 16th.

Warnings of a moderate cold wave in southeastern Colorado were issued on the morning of the 28th, when the pressure at Denver and Pueblo had fallen to 29.24 inches. From the temperatures reported from extreme western Kansas, the warning appears to have been verified over a portion of southeastern Colorado, although the fall at Pueblo amounted to but 14° during the following 24 hours, with a minimum of 36° reported from that station on the morning of the 29th.

A cold wave without warning occurred at Santa Fe and Durango on the morning of the 9th, although, as already stated, livestock warnings had been issued for southwestern Colorado and northwestern New Mexico. A local cold wave, without warning, also occurred at Pueblo on the morning of the 17th.

The following frost warnings were issued: 5th, 6th, 28th, and 29th, southern New Mexico; 8th, south central and southwestern New Mexico and southern and western Arizona; 9th, southwestern Arizona; 11th, south central and southwestern New Mexico; 12th, south central and southwestern New Mexico and southern Arizona; 15th, 16th and 22d, southern Arizona; 19th, south central and southwestern Arizona; 23d, southeastern New Mexico; 30th southern New Mexico and south central and southwestern Arizona.

Freezing temperature warnings were issued as follows: 5th, 8th and 17th, extreme southeastern New Mexico; 9th and 19th, southern New Mexico and southeastern Arizona; 13th, 16th and 22d, southern New Mexico; 30th, extreme southeastern New Mexico and extreme southeastern Arizona; 31st southern New Mexico.

As a rule, the conditions forecast were verified by temperatures favorable for the formation of frost, or by the occurrence of frost or freezing weather.—*J. M. Sherier.*

SAN FRANCISCO FORECAST DISTRICT

The pressure movements over this district during March, 1924, were of the type usually associated with early spring. The storms which entered the continent south of the international boundary, were of small area and rapid movement and developed greatly in energy after passing inland, while the large storms from the

north Pacific passed inland at a high latitude and exerted but little effect on the weather of the Pacific coast states.

During the last decade of the month a series of small storms, some moving southeastward from the Washington coast and others moving inland from off the northern California coast, passed eastward over the southern portion of the district and broke the long drought in California.

Storm warnings were ordered as follows: Northwest warnings at San Francisco on the 11th, and at Point Reyes on the 16th; and southwest warnings from Port San Luis to San Diego on the 20th.

Livestock warnings were issued in eastern Oregon and Idaho on the 14th; and in Nevada, Idaho, eastern Oregon and eastern Washington on the 18th, and 27th. The following commendation of these warnings is extracted from a letter received from the superintendent of the eastern Oregon branch of the Oregon Agricultural College:

"Many thanks for your telegrams relative to changes in weather conditions. This information was immediately given to our stockmen, and I assure you it was appreciated very much."

Frost warnings were issued as follows: 13th, in Oregon, 15th, Oregon and Washington; 16th, northern California; 18th, and 23d, Oregon and Washington; 25th, Oregon and Washington; 27th, northern California; 29th, interior of California; 30th, northern California and Oregon.—*G. H. Willson.*

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RIVERS AND FLOODS

By H. C. FRANKENFIELD, Meteorologist

Except for the floods of March 28–29 in the upper Potomac River, and on and after March 29 in the Monongahela and Ohio Rivers and their tributaries, no particularly destructive floods occurred in the principal rivers of the United States during March.

The Potomac River flood was caused by a combination of heavy rains with high temperatures that rapidly melted the heavy snow covering that had fallen over the drainage area during the month of March, from 3 to 4 feet remaining in the mountains at the time of the rains and high temperatures. In the North Branch of the Potomac River the flood was the greatest since the memorable flood of June 1, 1869, and in some localities was thought to have at least equaled the latter flood. Many towns were flooded, houses and bridges carried away, highways overflowed and destroyed, and great damage done in many other respects. In the town of Kitzmiller, Md., five lives were lost in the rush of the flood waters, but there were no other fatalities except one in the Shenandoah River near Harrisonburg, Va., and another at Washington, D. C.

The flood was particularly destructive in the vicinity of Cumberland, Md., but fortunately without loss of human life. The following report on the Cumberland flood was prepared by Dr. Harvey H. Weiss, river and cooperative observer and health officer of Cumberland:

During March, 1924, heavy snowfalls occurred throughout western Maryland. During most of the month all roads were blocked with drifts of snow, in some cases 15 to 20 feet high. The mountains were also covered with at least 3 to 4 feet of snow. On the morning of March 29, 1924, the maximum temperature having risen on the 28th to 65°, a heavy rainfall occurred, beginning at about 2 a. m. The rainfall between 2 a. m. and 8 a. m. was 1.63 inches. This rainfall, together with the snow washed down from various mountains, brought down a tremendous amount of water which emptied into the Potomac River, and at

8 a. m., March 29 the water had risen to 8 feet at the Cumberland, (Md.) gage. The reading on the 28th of March was 4 feet 3 inches.

Wills Creek which flows into the Potomac River at Cumberland was out of its banks at 8:30 a. m. At this time the lowlands along the river at Cumberland and also the lowlands of Ridgeley, W. Va., which is opposite Cumberland, were beginning to flood. The Potomac River rose at the rate of 1 foot per hour until 3 p. m. and then the rise was about 1½ foot per hour until 6 p. m., when the river remained stationary for about one hour and then began to recede. The river gage being only able to measure 10 feet, the height from 11 a. m. on was estimated by the observer. According to measurement after the water receded it was found that the river at the gage had reached a height of 19 feet 2½ inches. This reading may be high because of the fact that the water at the bridge may have been turbulent and therefore pushed higher than the actual level.

By 2 p. m. the entire lowland of Cumberland known as the "flats" was covered with 3 feet of water. Wills Creek flooded the main business section of Cumberland to a height of 3 feet. Mechanic Street, one of the main streets of the city, was like a river bed, the water rushing down the street at a great velocity. At 6 p. m. the crest of the flood was reached. By this time telephone, telegraph, and electric wires had been torn away, putting the city in complete darkness. Half of the west side of Cumberland was under 5 feet of water, and the center of the city contained about 4 feet of water. Most of the paving was washed away. The water had entirely receded at 5 a. m. on March 30 and cleaning up began immediately. There was no loss of life in Cumberland because of the flood. The property loss including railroad damage and bridges washed away was about \$4,000,000 at a conservative estimate. From all information available the water on March 29, 1924, was 2½ feet higher than at any previous time in the history of Cumberland.

The South Branch of the Potomac River was not so high, yet the flood was one of considerable proportions, and with the flood from the North Branch, caused a severe flood below the junction of the North and South Branches, overflowing all lowlands, tearing out banks of the Chesapeake & Ohio Canal in many places, flooding railroad tracks, and doing much other damage of a miscellaneous character as far as the mouth of the Shenandoah River, except in the vicinity of Harpers Ferry, W. Va., where the damage done was negligible, although the river reached a stage of 20.7 feet on March 30, or 2.7 feet above the flood stage. The rise in the Shenandoah River did not reach flood proportions, and as a consequence the flood below Harpers Ferry was not dangerous, although there was considerable overflow at various places.

The damage done by the flood probably amounted to as much as \$6,000,000 exclusive of railroad losses. Highway roads and bridges were reported to have been damaged to the extent of about \$1,500,000.

Warnings were first issued for the flood on March 29, but the early interruption of telegraph service above Cumberland prevented the receipt of accurate information, and the warnings were therefore not as effective as they would otherwise have been.

The conditions antecedent to the floods in the Monongahela River of West Virginia and in the streams tributary to the Allegheny River in Pennsylvania were very similar to those that caused the Potomac floods, although they were not nearly so destructive. The crest stage at Pittsburgh, Pa., was 29.2 feet, or 7.2 feet above the flood stage, on March 30, and the damage done in the Pittsburgh river district amounted to about \$1,000,000. However, the value of property saved through the accurate and timely flood warnings was reported to have been about \$10,000,000.

The flood waters continued down the Ohio River, and at the close of the month the river had passed the flood stage of 40 feet at Point Pleasant, W. Va., at the mouth of the Great Kanawha River. The crest stage at